CLAIMS

We Claim:

1. A method of printing a two-dimensional feature on substrate, said feature having first and second edges spaced in close proximity to one another, said method comprising the steps of:

(a) depositing a radiation-sensitive material on said substrate;

(b) providing a first mask image segment which corresponds to said first edge;

(c) exposing said first mask image segment with radiation using an imaging tool to produce a first pattern edge gradient, said first pattern edge gradient defining said first edge of said two-dimensional feature in said material;

(d) providing a second mask image segment which corresponds to said second edge;

(e) exposing said second mask image segment with radiation using said imaging tool to produce a second pattern edge gradient, said second pattern edge gradient defining said second edge of said feature in said material;

(f) developing said radiation-sensitive material, thereby reproducing said two-dimensional feature on said substrate.

Sub a1

2. The method as defined in claim 1 wherein said first and second edges are separated by distance which is less than or equal to the Rayleigh limit of said imaging tool.

3. The method as defined in claim 2 wherein said first and second edges are orthogonal.

4. The method as defined in claim 3 wherein said feature comprises a device contact of an integrated circuit, and said first and second edges define a corner of said contact.

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5. The method as defined in claim 2 wherein said first and second mask image segments comprise a single mask image having an area which is larger than said two-dimensional feature.

Sub a2

6. The method as defined in claim 2 wherein said first mask image segment is provided on a first mask and said second mask image segment is provided on a second mask.

7. The method as defined in claim 5 wherein said mask image is rectangular in shape, and said first mask image segment is substantially parallel to said second image segment.

8. The method as defined in claim 7 wherein step (d) comprises the step of offsetting said mask image relative to said substrate.

9. The method as defined in claim 2 wherein said material comprises a negative-acting photoresist layer.

10. The method as defined in either claim 5 or 6 wherein said first and second mask image segments each have associated therewith an additional sub-resolution edge segment, each of said additional segments being spaced a predetermined distance away from, and substantially parallel to, said associated mask image segment, said additional segments functioning to increase the slope of first and second patterned edge gradients to enhance said printing of said two-dimensional feature.

11. The method as defined in claim 10 wherein said predetermined distance is approximately 1.1 times the Rayleigh limit of said imaging tool.

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12. In a process for fabricating semiconductor devices, a method of printing a rectangular feature onto a photoresist layer deposited over a semiconductor substrate, said rectangular feature having at least two closely-spaced opposing feature edges, said method comprising the steps of:

Sub a3

decomposing said rectangular feature into a rectangular mask image having a pair of opposing mask edges of a length which is greater than or equal to the length of said opposing feature edges, said opposing mask edges being spaced apart a predetermined distance which is greater than the spacing between said opposing feature edges;

exposing a first one of said mask edges with radiation using an imaging tool to produce a first pattern edge gradient which defines a first one of said feature edges in said photoresist layer;

offsetting said rectangular mask image relative to said substrate;

exposing the second one of said mask edges with radiation using an imaging tool to produce a second pattern edge gradient defining the second one of said feature edges in said photoresist layer.

13. The method as defined in claim 12 wherein said spacing between said opposing feature edges is less than or equal to the Rayleigh limit of said imaging tool.

Sub a4

14. The method as defined in claim 13 wherein said predetermined distance is greater than said Rayleigh limit.

~~15~~ 14. The method as defined in claim ~~14~~ 13 wherein said offsetting step offsets said mask image a distance approximately equal to said predetermined distance minus said spacing.

~~16~~ 15. The method as defined in claim ~~14~~ 13 wherein said rectangular feature is a square.

16 ~~17~~. The method as defined in claim 13 ~~14~~ wherein said decomposing step includes the step of calculating the length of said mask edges as having a minimum dimension, D, which is given by the equation

$$D = S + (\lambda/NA)$$

where S is the length of said feature edges, λ is the wavelength of said radiation, and NA is the numerical aperture of said imaging tool.

Sub a5

18. The method as defined in claim 13 wherein said pair of mask edges each have associated therewith an additional sub-resolution edge segment, each of said additional segments being spaced a certain distance away from, and substantially parallel to, said associated mask edge, said additional segments functioning to increase the slope of said first and second pattern edge gradients, thereby enhancing said printing said rectangular feature.

18 ~~19~~. The method as defined in claim 17 ~~18~~ wherein said certain distance is approximately 1.1 times said Rayleigh limit.

19 ~~20~~. The method as defined in claim 14 ~~15~~ wherein said photoresist comprises a negative-acting resist layer.

Sub a6

21. A process for fabricating an integrated circuit (IC) on a silicon substrate using a lithographic tool, an imaging decomposition algorithm for printing an array of square contacts having an edge dimension which is less than or equal to the Rayleigh limit of said lithographic tool comprising the steps of:

(a) calculating a minimum critical dimension (CD) for said printing process based on said edge dimension;

(b) forming a plurality of decomposed image squares, each of said corresponds to one of said contacts within said array, said image squares having a dimension which is greater than or equal to said minimum CD;

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(c) calculating the minimum horizontal, vertical and diagonal pitches required between adjacent contacts within said array based upon a process of decomposing each of said contacts by sequentially exposing each edge of said image squares with radiation to produce the corresponding edge of said contacts on said substrate, said squares being offset relative to said substrate prior to each subsequent exposure in said sequence to align each of said image square edges to said corresponding edges of said contacts;

Sub a6 cont'd

(d) identifying as belonging to a first set of contacts, which of said adjacent contacts in said array violates said pitches, said contacts which are not identified as belonging to said first set being included in a second set;

(e) forming a first decomposed image mask comprising the image squares corresponding to said second set of said contacts; and

(f) forming a second decomposed image mask comprising the image squares corresponding to said first set of said of contacts.

~~22~~ 21. The algorithm as defined in claim ~~21~~ 20 wherein said critical dimension is defined by the equation

$$CD = S + (\lambda / NA)$$

where S is the length of said edges of said contacts, λ is the wavelength of said radiation, and NA is the numerical aperture of said lithographic tool.

Sub a7

23. The algorithm as defined in claim 22 wherein said minimum horizontal and vertical pitches is defined as N, where N is equal to CD, and said minimum diagonal pitch is defined as M, where M is given by the equation

$$M = \sqrt{2}\,(\lambda / NA).$$

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